

WEATHER NOTE

AIRCRAFT OBSERVATIONS IN THE IMMEDIATE VICINITY OF TWO WATERSPOUTS

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ABSTRACT

Two waterspouts were observed aloft from a private aircraft recently near Lower Matecumbe Key, Florida. Color slides and zoom movies of both waterspout vortices on the sea surface and aloft were obtained. A detailed description of the equipment used and a discussion of the synoptic pattern of that day are presented. The data show some interesting details regarding the dynamics of the observed waterspout circulations. Both waterspouts traversed a similar path. A subsequent ground survey of the paths taken over the Key, together with damage reports and eyewitness accounts, indicate that the second waterspout was much more intense than the first.

The authors plan to make detailed calculations, using the zoom movies, of a radial profile of the tangential and vertical wind speeds about the second waterspout vortex. Rates of forward motion and funnel diameter at various levels below the cloud base will also be obtained. An additional, more quantitative report of this interesting encounter will be forthcoming.

1. INTRODUCTION

On a pleasure flight from Key West to Miami, Fla., the authors encountered a line of cumulus congestus clouds, tops not exceeding 20,000 ft., which spawned two waterspouts and a third funnel which failed to reach the water. These cyclonically rotating spouts were seen between 1530 and 1615 EST on September 2, 1967, moving on tracks which carried them across Lower Matecumbe Key (fig. 1). The second and more vigorous waterspout was still quite intense when observations were discontinued after 20 min. due to a lack of film and fuel.

Color slides and movies were taken of both waterspouts from altitudes ranging from 2,000 down to 800 ft. The movies provide a complete and possibly unique view of the waterspouts in that they were taken from aloft; they are currently being used to make a detailed calculation of a radial profile of the tangential speed about the second waterspout vortex. The movies will also permit inferences as to the vertical motions in and around the funnels.

The authors returned to Lower Matecumbe Key to document the passage of the waterspouts across the island. Eyewitness accounts were obtained. Movies and slides taken by residents of the Key will be available at a later date.

2. DATA SOURCES

The aircraft used for observation was a privately owned, twin-engine Piper Apache flown by one of the authors.

The pattern flown about the waterspouts was a simple circle to the right at airspeeds averaging 130 m.p.h. Flight altitude averaged 2,000 ft. but was 800 ft. while zoom movies were taken of the waterspout vortex at its intersection with the sea surface.

During the period of observation both 35-mm. color slides and Super-8, 8-mm. color movies were taken. The slides were taken with a Leica model M3 camera equipped with the following three types of lenses: regular Summacron 35 mm., Leitz 35 mm. Summaron f/2.8 wide angle lens, and Canon f/3.5 90-mm. telephoto lens. The wide angle lens was used to give vertical shots of the entire waterspout funnel from cloud base to the sea surface, covering a 64° field of view. One telephoto slide, at a magnification of about 5×, was taken of the waterspout vortex at the sea surface.

The 8-mm. movies were taken with a new Canon Super-8 Zoom 518, with a zoom ratio of 5:1 and an electrically driven film speed of 18 frames per second. Most of the movies were taken at maximum zoom showing the second fully extended waterspout.

Twenty-seven color slides were taken using all three bayonet-type lenses. Most of the slides document the first fully extended waterspout and its passage across Lower Matecumbe Key into Florida Bay.

3. SYNOPTIC SITUATION

The large-scale flow regime over Florida and the Florida Keys on the afternoon of September 2 was

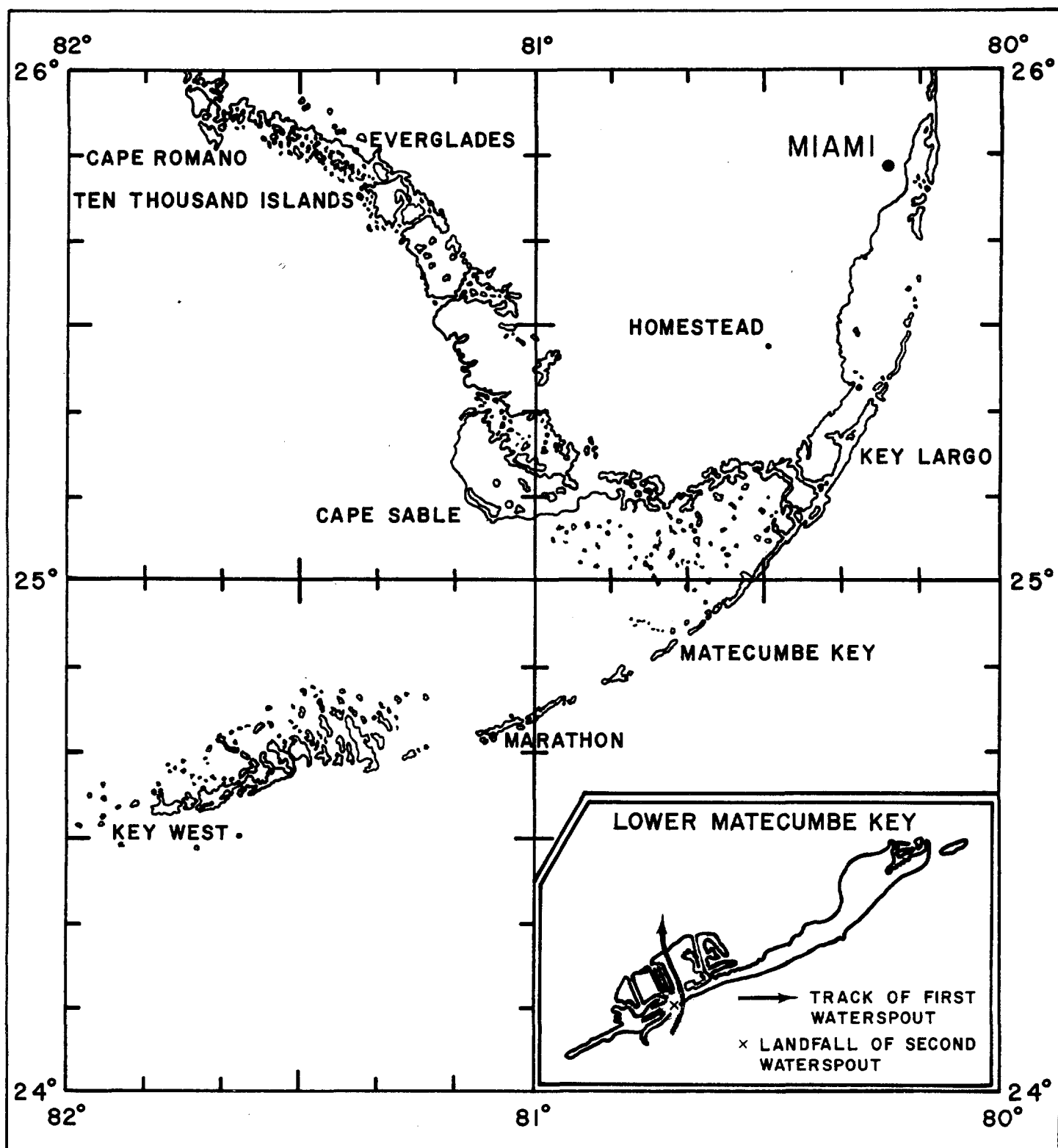


FIGURE 1.—Map of South Florida and the Florida Keys, with inset showing Lower Matecumbe Key in greater detail. Track of first observed waterspout has been inferred from photographs and eyewitness accounts.

characterized by a short-wave trough in the middle and upper tropospheric westerlies which had just passed to the east. At levels up to 10,000 ft. on the Key West rawinsonde

(September 3, 0000 GMT), the winds were light south-westerly (less than 6 kt.), gradually veering with height. Ship reports in the Keys indicated very light and variable

winds at the surface. The Key West sounding also showed a moderately moist lower troposphere below 700 mb. with drier air above. A rather unusual and marked inversion of $3.5^{\circ}\text{C./8 mb.}$ was found at 550 mb. The stability index of the air mass over Key West was computed as $+3$ by the Showalter method, which neglects the low level moisture distribution in the sounding. This value is considered by many forecasters to represent moderate stability. However, numerous thunderstorms developed late that afternoon over South Florida and the Upper Keys.

The late afternoon WSR-57 radar observations from Miami depicted scattered echoes, mainly over the South Florida peninsula. In this area there were isolated tops of 40,000–50,000 ft. However, there were few if any echoes detected in the Keys southwest of Key Largo (fig. 1) during this period. There was one echo (about 3.5-n.mi. diameter) just over and south of Lower Matecumbe Key at 1545 EST, which corresponds with the location and time of the first waterspout sighting. Visual estimates by the authors placed the tops in the cumulus cloud line across Lower Matecumbe Key near 20,000 ft. None of the clouds in this line reached cumulonimbus proportions,

although showers fell from a few cells in the line. The clouds which spawned the waterspouts produced only a brief splattering of very large drops on the aircraft windshield. Even though only very light turbulence was encountered while circling the waterspouts, observations of their circulations suggested that penetration of the funnels would be folly.

4. OBSERVATIONS OF THE WATERSPOUTS

The first waterspout was sighted at 1535 EST a short distance south-southwest of Lower Matecumbe Key moving from the south-southwest. The funnel was narrow, with preliminary calculations indicating a diameter varying between 40 and 80 ft. (fig. 2). The funnel is approximately 2,500 ft. long extending from cloud base to the water. The visible portion of the funnel, which is thought to consist of condensation moisture, extended about two-thirds of the way from cloud base to the ocean. The central portion of the funnel was observed to be hollow. Ocean spray was picked up by the spout and circulated upward as a sheath around the periphery of the visible funnel. One measurement showed the spray to extend to at least 500 ft. above the sea surface. The track of the waterspout was evident as a narrow wake of disturbed water a considerable distance to the rear of the vortex.

Figure 3 shows the funnel just before it made its landfall on Lower Matecumbe Key, and figure 4 shows it onshore. Note that the visible funnel has retracted and appears somewhat weaker. This is corroborated by eyewitness accounts on the Key which indicate that the waterspout appeared to dissipate as it moved onshore. Aircraft observations show that the funnel circulation persisted near cloud base and extended to the water again as a very narrow rope-like spout after it crossed the Key. Figure 5 shows the reformation of the waterspout. The vortex can be seen in the water with the narrow funnel visible some



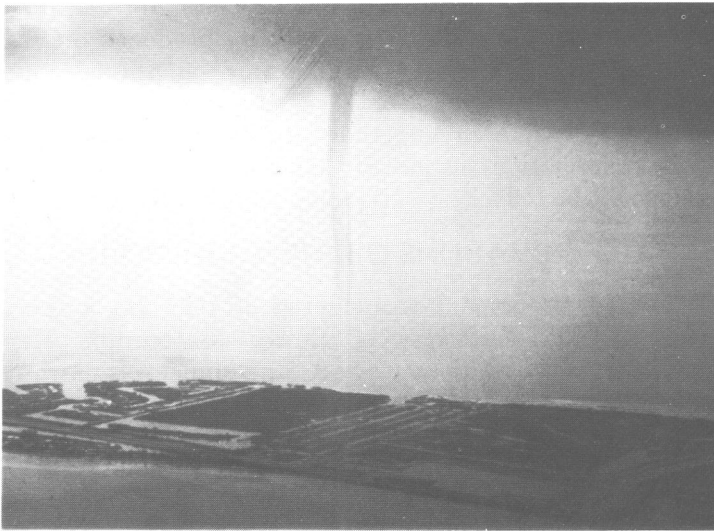
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FIGURE 2.—First waterspout offshore, looking northwest, with Lower Matecumbe Key in background.



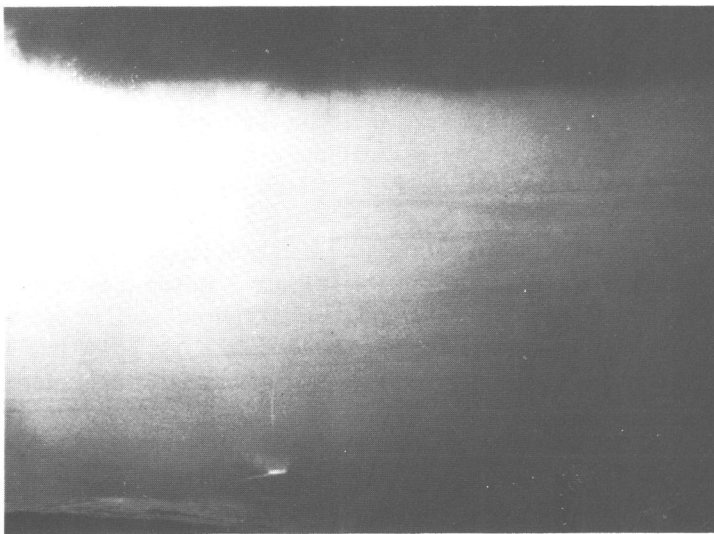
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FIGURE 3.—First waterspout just before landfall, facing south.



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FIGURE 4.—First waterspout soon after landfall, looking northwest.



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FIGURE 5.—First waterspout shortly after passage over Lower Matecumbe Key. At this time, the waterspout funnel is reforming.

distance below cloud base. The major portion of the circulation was invisible to the naked eye. After this picture was taken the visible funnel extended most of the way to the water and began to broaden out. At about the same time a second funnel some distance away dropped a short distance from cloud base and then dissipated. The first waterspout was monitored for 15 min. but had a lifetime exceeding this figure.

The first waterspout was beginning to weaken when the third and most vigorous funnel was sighted a few miles to the south-southwest. Its funnel was larger than the other two and like the first extended to the sea surface. This waterspout was essentially vertical, although it had a slight tilt or slope at times (figs. 6 and 7). Aircraft observations of this spout commenced at 2,000 ft. but descent to 800 ft. was initiated to better observe and photograph the spectacular features of the circulation in



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FIGURE 6.—Second waterspout south of Lower Matecumbe Key, looking northwest. The size of the visible funnel may be compared with that in figure 5.

the water. Observations of the spray are being used to calculate wind speeds about this vortex. Viewed from above, the vortex at the surface resembled a miniature hurricane with a central calm core and a rapidly rotating region at the core boundary. At some distance from the funnel the spray was thrown outward and upward about the periphery of the visible funnel. One slide was taken of the surface vortex and is shown in figure 8. The calm core is not visible here because it is obscured by spray. Later the aircraft was flown in a tight circle about the funnel permitting observation into the center of circulation. During this period zoom Super-8 movies were taken.

After studying this waterspout for 20 min., the authors were forced to terminate observations at 1605 EST because of a lack of film and fuel. At this time the waterspout appeared to be as vigorous as it was when first detected. No information was available on the later behavior of this waterspout until we subsequently visited Matecumbe Key.



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FIGURE 7.—Another view, looking east-northeast, of the second waterspout. Note narrow wake extending to rear of surface vortex.



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FIGURE 8.—Telephoto view of the surface spray vortex, with wake clearly visible in the lower right.

Later observations on the ground confirmed that residents of this Key had watched the passage of two waterspouts over the island in roughly parallel tracks. It was determined that the two waterspouts made landfall within 50–100 yd. of each other. The first was definitely the weaker of the two. No one on the island recalled any damage caused by the first spout; however, its surface winds could be followed part of the way across the island both from the aircraft and from the ground. The second left some striking evidence. A house more than 50 yd. inland had its metal awnings irreparably twisted and bent and sections of an adjacent fence were torn apart. Eyewitnesses claimed that a 1965 Cadillac parked in front of the house was “lifted up a few feet off the ground.” In this same house and another farther inland doors and cupboards popped open as the funnel passed suggesting a rapid change of pressure. Outside, bushes were flattened and uprooted in the direction of motion of the funnel. Part of a fence was blown almost $\frac{1}{10}$ mi.

The time when the second waterspout struck the Key can be specified rather well because a power loss stopping an electric clock occurred at 1615 EST. This agreed well with the estimates of other witnesses. As stated previously, the aircraft had left the area before this time.

The ground survey was useful in other respects. Two eyewitnesses described peculiar pulsations in the diameter of the funnel, much like “a bird flapping its wings.” This may be related to periodic pulsations observed from the aircraft and recorded on the movie film. Other witnesses helped the authors locate objects, such as highway signs, which had been blown away. The initial and final positions of these objects were mapped. It was soon evident that debris was moved not only in the direction of the track of the storm but also in other directions.

5. CONCLUSIONS

A rather cursory and descriptive look at a unique set of observational waterspout data has been given here. Details described are shown clearly in the original color prints but some are obscured in the reproductions (figs. 2–8*). The authors are presently calculating the distribution of velocities in the wind-driven sea spray. From these photogrammetric calculations, inferences will be made as to the wind profile in the lower portion of the waterspouts. Also, other interesting aspects, including energetics, of the waterspout circulation as revealed by the movies will be investigated.

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